Occurrence of the 2:1 commensurability in a gas giant-Super-Earth system

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We investigate how the conditions occurring in a protoplanetary disc may determine the final structure of a planetary system emerging from such a disc. We concentrate our attention on the dynamical interactions between disc and planets leading to orbital migration, which in turn, in favourable circumstances, can drive planets into a mean-motion commensurability. We find that for a system containing a gas giant on the external orbit and a Super-Earth on the internal one, both embedded in a gaseous disc, the 2:1 resonance is a very likely configuration, so one can expect it as an outcome of the early phases of the planetary system formation. Our conclusion is based on an extensive computational survey in which we ask what are the disc properties (the surface density and the viscosity) for which the 2:1 commensurability may be attained. To answer this question we employ a full two-dimensional hydrodynamic treatment of the disc-planet interactions. In general terms, we can claim that the conditions which favour the 2:1 mean-motion resonance exist in the protoplanetary discs with mass accretion rates typical for slowly accreting T Tauri stars. For accretion rates higher than those needed for the 2:1 commensurability we observe a variety of behaviours, among them the passage to the 3:2 resonance, the scattering of the Super-Earth or the divergent migration caused by the outward migration of the gas giant. The results we have obtained from numerical simulations are compared with the predictions coming from the existing analytical expressions of the migration speed and the strength of the mean motion resonances. The conditions that we have found for the attainment of the 2:1 commensurability are discussed in the framework of the properties of protoplanetary discs that are known from the observations.

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